

Application No. 10/089,578
Filed: August 12, 2002
TC Art Unit: 1754
Confirmation No.: 2516

REMARKS

Claims 1-34 have been rejected under 35 U.S.C. § 103 as being unpatentable over U.S. Patent No. 3,947,547 to Groenendaal et al. in view of *Gas Purification*, 4th edition, by Kohl et al.

Claims 1-34 are pending in the present application. Claim 1 is amended herein and support for the amendment can be found throughout the specification and claims as originally filed. Additionally, claim 26 has been cancelled. The amendments made herein are further explained below. No new matter has been added. Accordingly, claims 1-25 and 27-34 will be pending upon entry of the amendments herein.

Any amendments to the claims should in no way be construed as acquiescence to any of the Examiner's rejections and was done solely to expedite the prosecution of the application. Applicants reserve the rights to pursue the claims as originally filed in this or a separate application(s).

Applicants respectfully request reconsideration and withdrawal of the Examiner's rejections in view of the above amendments and the remarks herein.

Claims Rejections - 35 U.S.C. § 103

Claims 1-34 have been rejected under 35 U.S.C. § 103 as being unpatentable over U.S. Patent No. 3,947,547 to Groenendaal et al. in view of *Gas Purification*, 4th edition, by Kohl et al.

Applicants respectfully traverse the foregoing rejections.

Applicants claim a process by amendment for the selective catalytic reduction of the sulfur dioxide content in a gas mixture. The reduction occurs as the gas mixture is passed over a sulfur resistant hydrogenation catalyst in sulfidic form. The

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process also includes a second oxidation step in which the resulting gas mixture is oxidized via a dry bed. One advantage of the process is greatly improved sulfur recovery.

Claim 1 recites the disclosed process. Applicants amended claim 1 such that the process is directed to "selective catalytic" reduction. By amendment, Applicants also claim that the gas mixture to be reduced "compris[es] sulfur dioxide, [and] sulfur vapor." Lastly, claim 1 is amended to recite that the resulting gas mixture to be oxidized comprises "less than 1.2 vol[ume] % H_2S ."

For the Examiner's convenience, the entire text of claim 1 is provided below.

1. Process for the selective catalytic reduction of sulphur dioxide content of a gas mixture comprising sulfur dioxide, sulfur vapor, and at least 10 vol.% of water, in which process the gas mixture is passed over a sulphur resistant hydrogenation catalyst in sulphidic form, at a space velocity of at least 2000 h^{-1} , in the presence of a reducing component, in a molar ratio of reducing component to sulphur dioxide of more than 10 up to 100, at a temperature of 125°C to 300°C , thereby producing a resulting gas mixture comprising less than 1.2 vol. % H_2S , followed by passing the gas mixture, after the said reduction, through a dry oxidation bed for the oxidation of sulphur compounds to elemental sulphur.

Now, turning to Groenendaal et al., the Examiner states that Applicants' prior remarks concerning sulfur dioxide being selectively removed from the gas mixture were not convincing as Applicants' "claims do not require that sulfur components other than sulfur dioxide be present in the gas mixture." By amendment, Applicants require that sulfur dioxide and sulfur vapor both be present in the gas mixture that is to be processed. This

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amendment is supported by the specification. For example, page 8, lines 21 through 25 describes that the reduction of SO₂ proceeds faster than the reaction of sulfur vapor and hydrogen to H₂S. Table 2 of the specification also indicates that sulfur components other than sulfur dioxide are present in the gas mixture to be processed.

Additionally, Groenendaal et al. teach a process in which all of the sulfur dioxide and other reducible sulfur compounds from a Claus off-gas are hydrogenated to hydrogen sulfide. To be more specific, Groenendaal et al. introduce hydrogen-containing gas to the Claus off-gas "in a quantity which is sufficiently large to reduce to hydrogen sulfide **all** the sulfur dioxide and other reducible sulfur compounds." See column 3, lines 45 through 49. Thus, the process disclosed in Groenendaal et al. operates at conditions in which sulfur dioxide and other sulfur compounds are **entirely** reduced to hydrogen sulfide. As noted, one particular operating condition taught in Groenendaal et al. is that there be a quantity of hydrogen sufficient to reduce **all** the sulfur dioxide and other sulfur compounds to hydrogen sulfide.

In contrast, Applicants recite a process in claim 1 that does not hydrogenate **all** of the sulfur dioxide or other sulfur compounds present in a Claus off-gas. The Examiner argues that "there is no evidence on record showing" that the claimed process would not also reduce **all** of the sulfur dioxide or other sulfur compounds. Applicants, again, respectfully guide the Examiner to Table 2 which illustrates that **not all** of the sulfur dioxide or sulfur vapor is reduced by the claimed process. What's more, Table 2 shows only trace amounts of the other sulfur compounds are reduced at all. Such evidence supports that the claimed process

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selectively reduces sulfur dioxide, rather than reducing sulfur dioxide and other sulfur compounds to hydrogen sulfide as taught by Groenendaal et al.

The Examiner explains in detail that Groenendaal et al. teach an excess of hydrogen-containing gas present in the Claus off-gas. The Examiner also suggests that it would be *prima facie* obvious to use the teachings regarding an excess of hydrogen-containing gas to practice the molar ratio of hydrogen to sulfur dioxide recited by Applicants. Applicants respectfully disagree with the Examiner as Groenendaal et al. fail to particularly disclose a "more than 10 up to 100" ratio of reducing component to sulfur dioxide as recited in claim 1. More notably, Groenendaal et al. fail to recite such a ratio for a process involving the *selective* reduction of sulfur dioxide. Applicants, again, underscore that Groenendaal et al. is directed to a process for reducing *all* sulfur dioxide and other sulfur compounds to hydrogen sulfide. Thus, Groenendaal et al. teach producing hydrogen sulfide from an excess of hydrogen-containing gas via reduction, and not the *selective* reduction of sulfur dioxide.

Applicants' prior remarks regarding Groenendaal et al. teaching the reduction of sulfur dioxide and other sulfur compounds to hydrogen sulfide were unconvincing to the Examiner. In particular, the Examiner states that the claimed process would not necessarily contain a lower amount of hydrogen sulfide after hydrogenation than Groenendaal et al. Applicants respectfully disagree with the Examiner, asserting that the claimed process is not directed to producing hydrogen sulfide by the reduction of sulfur dioxide and other sulfur compounds. The Examiner is

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respectfully guided to Table 2 which shows that the claimed process fails to produce large quantities of hydrogen sulfide.

Applicants do not produce hydrogen sulfide by the reduction of sulfur dioxide and other sulfur compounds due to the kinetics involved in the claimed process. Specifically, Applicants discovered that sulfur dioxide could be *selectively* hydrogenated as the chemical reactions reducing sulfur dioxide proceed faster than the reaction of sulfur vapor and hydrogen to hydrogen sulfide. See specification page 8, lines 21 through 25. Moreover, by practicing catalytic hydrogenation at a high reactor space velocity, Applicants observed that the reduction kinetics allowed sulfur dioxide to be *selectively* reduced. Furthermore, a high reactor space velocity aids the hydrogenation of sulfur dioxide without reducing other sulfur compounds, or producing hydrogen sulfide. The high reactor space velocities shown in Table 2 support that the claimed process does not reduce other sulfur compounds, or produce hydrogen sulfide. The slow reduction kinetics producing hydrogen sulfide, in addition to the high reactor space velocity practiced by Applicants, guided the amendment of claim 1 to recite that the gas mixture resulting from hydrogenation comprises *less than 1.2 volume % of hydrogen sulfide*.

Groenendaal et al. teach those in the art that practicing the disclosed process produces large quantities of hydrogen sulfide. These large quantities of hydrogen sulfide are treated through contact with an adsorbent or absorbent. See column 5, lines 30 through 33. Applicants' process, however, does not require this type of additional unit operation to remove an undesired excess of hydrogen sulfide. Nonetheless, the Examiner suggests that it

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would be obvious to combine Groenendaal et al. with the teachings of Kohl et al. to practice Applicants' claimed oxidation step using a dry oxidizing bed. Applicants respectfully disagree with the Examiner as one of skill in the art would not be motivated to practice the dry oxidizing bed disclosed in Kohl et al. to treat a large quantity of undesired hydrogen sulfide. Similarly, Applicants' process is directed to **selective** catalytic reduction of sulfur dioxide which, as discussed, is different from hydrogenating sulfur compounds and hydrogen to hydrogen sulfide.

Although dry bed oxidation techniques were understood and practiced in the art prior to Groenendaal et al., the reference specifically teaches away from dry bed oxidation by instead disclosing the use of **solutions** having an oxidizing nature. See column 5, lines 54 through 55. Applicants contend that Groenendaal et al. does not use a dry oxidizing bed as the cited process produces an excessive amount of hydrogen sulfide. Such large quantities of hydrogen sulfide are known in the art to cause a dry oxidizing bed to experience an extreme temperature increase, as well as a reduced heat capacity. The Examiner, however, stated that Applicants' prior remarks identifying these problems were unconvincing because the claimed process did not require a minimum quantity of hydrogen sulfide in which it would be feasible to use a dry oxidizing bed. By amendment, Applicants require that the resulting gas mixture contain a quantity of hydrogen sulfide that would be feasible to oxidize, without the problems noted above, via a dry bed in the second oxidation step of the claimed process.

In a concluding argument, the Examiner indicates that it would be obvious, based on Groenendaal et al., to modify the discontinuous dry oxidation process of Kohl et al. to be

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continuous such as that disclosed in the claimed process. Applicants respectfully disagree with the Examiner's argument as it is based on a lack of understanding of the teachings of Groenendaal et al. As discussed, Applicants' process is directed to *selective* catalytic reduction of sulfur dioxide which does not produce large quantities of undesired hydrogen sulfide. Thus, one of skill in the art would not be motivated to modify the teachings of Kohl et al. to practice a continuous second oxidation step using a dry oxidizing bed.

In view of the foregoing amendments, Applicants respectfully request reconsideration and withdrawal of the foregoing rejections.

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CONCLUSION

Based on the foregoing, entry of the amendments and remarks presented herein, reconsideration and withdrawal of all the rejections and allowance of the application with all pending claims are respectfully requested.

The Examiner is encouraged to telephone the undersigned attorney to discuss any matter that would expedite allowance of the present application.

Respectfully submitted,

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